APPROPRIATE DESIGN OF LOESS DOMINANT DUMPING AREA AT OPEN PIT COAL MINE IN CHINA

张，东华

https://doi.org/10.15017/1500715

出版情報：九州大学, 2014, 博士（工学）, 課程博士
バージョン：

（様式２）

氏　　名　：張 東華

論 文 名　：APPROPRIATE DESIGN OF LOESS DOMINANT DUMPING AREA AT OPEN PIT COAL MINE IN CHINA
（中国の露天掘り石炭鉱山における黄土卓越廃石場の最適設計に関する研究）

区　　分　：甲

論 文 内 容 の 要 旨

Recently, extraction depths have been deeper and the sizes of extractions have been bigger in Chinese open pit coal mines because the demand of coal has been increasing rapidly with the development of domestic industry. More than half of all major open pit coal mines are located in the loess plateau where loess is dominant near the surface layer. The porosity of loess is very high and its mechanical properties decline significantly after absorbing water. Therefore, instability and collapses of dominant loess dumping areas due to either rain or a rising ground water level are serious problems in these mines. For this reason, it is necessary to develop design guidelines and stabilization measures for predominant loess dumping, considering both the properties of loess for operational safety as well as a certain coal output. From this background, this study proposes the guidelines for an appropriate design of a stable dumping site in areas where loess is dominant near the surface, along with countermeasures to improve the stability of the dumping site at these major open pit coal mines in China.

Chapter 1 introduces the background of this research including the current condition of the Chinese coal mining industry, the geotechnical issues of predominant loess dumping sites at open pit mines, the characteristics of loess, study objectives, and an involved outline of the dissertation.

Chapter 2 discusses a large slope failure which occurred at the South dumping site in Antaibao coal mine located in the loess plateau in order to clarify the mechanisms which caused the failure by means of site investigation and numerical analysis. From these results, the changes in the mechanical properties of loess by the elevation of the groundwater level associated with rainfall and a weak loess floor layer may lead to this large slope failure at dumping sites. These two main factors must be considered for the construction of dumping sites in order to develop specific guidelines for the appropriate designs of stable dumping sites in areas where loess is dominant near the surface, along with countermeasures to improve the stability of these dumping sites.

Chapter 3 discusses the effects of water content on the mechanical properties of loess and the stability of dumping areas by means of laboratory tests and numerical analysis. From the results of laboratory tests, it can be seen that the mechanical properties of loess, such as the internal friction angle and cohesion, dramatically decrease with increases in water content; the internal friction angle changed from 42° to 32°, and the cohesion changed from 110 kPa to 41 kPa when the water content changed from 15% to 25%. From the results of a series of numerical analysis, it can be seen clearly that stability significantly decreases with

increases in the water content of loess and then the available height of dumping pile decreases dramatically. For these reasons, the height of dumping sites must be less than 125 m from 150 m when the moisture content changes from 15% to 25% in accordance with guidelines for the construction of dumping sites by the mining department in China, which has a safety factor of 1.5, in cases where the footwall of the dumping site is horizontal and has a 20 degree slope angle. This result indicates that the dumping capacity in the dumping area is decreased, significantly. Additionally, the height of a dumping site and its stability can be increased by decreasing the slope angle. From these results, guidelines for the improvement of stability are suggested, indicating the importance of drainage systems to decrease the groundwater level and water content of loess dumping sites in order to maintain the stability of the predominant loess dumping site and its dumping capacity.

Chapter 4 discusses the effects of weak floor layers, which consist of loess, on the stability of dumping sites by means of numerical analysis. As a result, it can be recognized that the dumping pile deforms and then the stability of dumping sites is reduced dramatically when there is a weak floor layer which consists of loess. Moreover, the stability of a dumping pile is reduced with an increase in the thickness of the loess floor layer. Therefore, the application of a compacted layer built using heavy equipment is proposed as a technique to improve the stability of dumping sites with weak floor layers. According to the results obtained from numerical analysis, the application of a 1.5 m thick compacted layer makes it possible to meet the required safety factor of 1.5 for dumping sites; the criteria of a stable dumping site issued by the mining department in China when the thickness of a weak floor layer is 20 m and the height of the dumping pile is 30 m. Also, since the compacted layer has a low permeability of around 4.0×10^{-7} cm/sec, it is effective in not only minimizing the strength reduction in the bottom part of the floor layer due to infiltrating rain water, but also in controlling the drainage of the dumping pile. From the results obtained so far, the installation of drainage holes and the formation of compacted layer on top of weak floor layers are proposed as countermeasures to improve the stability of the dumping site. As a result of numerical analysis, it was concluded that the application of this countermeasure improves the safety factor of a dumping site from 1.0 to 1.6.

Chapter 5 investigates the mechanisms involved in dumping pile formation as well as an appropriate dumping system by means of laboratory tests. At first, the effects of the particle size of waste rock on the formation of a single pile are discussed. It can be seen that both the slope angle and the height of a dumping pile can be increased with a decrease in the particle size of waste rock. Therefore, it can be said that the volume of dumping material per unit area can be increased by controlling the particle size of the rock. Next, the interval distance, dumping volume and dumping height are varied to examine the interaction between the formations of multiple piles. As a result, it can be said that the volume of dumping material per unit area can be increased by decreasing the interval distance, because the height of a dumping pile is increased dramatically due to the increasing effects of the next dumping piles when the interval distance is small. Moreover, land reclamation at the dumping piles must be carried out after dumping work. Therefore, the elevation difference is measured to examine the amount of grading work required under different dumping conditions. As a result, the elevation difference decreases as the interval distance and total volume of dumping material per pile decreases. The results show that both the cost and required work of grading operations can be reduced by accounting for the appropriate interval distance and the volume of dumping material for each dumping pile after considering the bucket volume and the dumping system.

Chapter 6 concludes the results of this study.